3.—Wave-Cut Platforms At Yampi Sound, In The Buccaneer Archipelago, W.A.

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The section of the Northwest coast of Western Australia that lies between King Sound and Collier Bay, and which includes Yampi Sound and the Buccaneer Archipelago, is a drowned or submergent coast, with narrow, nearly straight, sub-parallel sounds or inlets, up to 5 or 10 miles long, extending out into channels between chains of islands (Fig.1). The rocks of the region are folded to overfolded mica schists, chlorite schists, quartzites, hematite quartzites, and occasional beds of hematite, intruded in parts of the mainland by sills of quartz-felspar porphyry (Canavan and Edwards, 1938). The long axes of the sounds or inlets, the channels, and the chains of islands trend more or less northwest, parallel to the strike of the major fold axes. From King Sound to Yampi Sound the coast trends at right angles to these structures, and is of the *Ria* type. From Yampi Sound east to Collier Bay, however, the coast parallels these structures, so that this section of the coast is of the *Dalmatian* type.

Apart from a few small pocket beaches, and some protected and mangrove-infested inlets, the coastlines are cliffed, the cliffs ranging in height from a few feet to several hundred feet, according to the composition of the rocks and the dips of the beds. The islands and the mainland are generally bounded by fringing coral reefs, in places narrow, but up to 200 yards wide.

The average tidal range in this region is about 30 ft., increasing to 33 ft. at spring tides, and up to 36 ft. at "king" tides; and to a height of 30 ft. above the reef level the rocks are stained black. The striking horizontal black band that results extends up from the inner level of the reef to the average high water mark all around the rocky coast of the islands and the mainland, and contrasts strongly with the buff, ochreous, brown, red-brown and white rocks immediately above it (Fig. 2). At close quarters the top of the black band cannot be defined over a depth of about 12 in., but seen from 100 ft. or more, it appears as a sharp line, and provides a useful datum by which to compare the height of the occasional rock stacks and the many rock platforms that occur along sections of the coast.

The waters within the sounds and in the channels are commonly calm or mildly choppy, with waves only occasionally reaching a height of 4 ft., even in exposed positions. During the wet season (summer), however, the region is subject to winds from the N. and N.E. of up to 100 miles per hour, when all exposed sections of the coast are subjected to violent wave attack.

Strong S.E. winds blow occasionally at other times in King Sound, to the west of the Archipelago, but fail to produce comparable storms, although they give rise to rough seas in the western approaches of the Archipelago.

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Rock Platforms

Rock platforms are a feature of the coasts of a number of the islands, and of long sections of some of the inlets. These platforms end abruptly on their landward sides against vertical cliffs. Their surfaces are horizontal or slope to seaward at 5° - 10°, and at their seaward edges end abruptly in "a low tide cliff", or more commonly in a ramp inclined at 25° - 45°. The surfaces of the platforms are invariably at or just below the top of the black band, i.e., the mean high tide level, so that they are covered at spring tides on calm days.

Platforms along Inlets

Platforms at mean high tide level extend along both cliffy walls of some of the long narrow inlets or sounds, like Copper Mine Inlet. The platforms are 5 to 15 ft. wide, and resemble parallel roads cut in the cliffs at high tide level. Their surfaces are relatively smooth, and horizontal, or have a gentle slope seaward. They end abruptly in a steep slope to the low tide level.

Two features of these platforms seem significant:—

(i) They extend up the inlet to a point where the inlet becomes choked with mangroves, and for considerable parts of their lengths there is a growth of mangroves on their steeply sloping seaward edge. This mangrove growth is thin and stunted where it is nearest to the open sea, but becomes a more vigorous growth further up the inlet. Evidently the wave action required to cut these platforms, and maintain them, is a very weak one.

(ii) The platforms are found only where the walls of the inlet consist of quartz-felspar porphyry or of schists. Where the walls consist of quartzites, the platforms cease abruptly, and a smoothly sloping bare rock wall is present, with no notch at the high tide level.

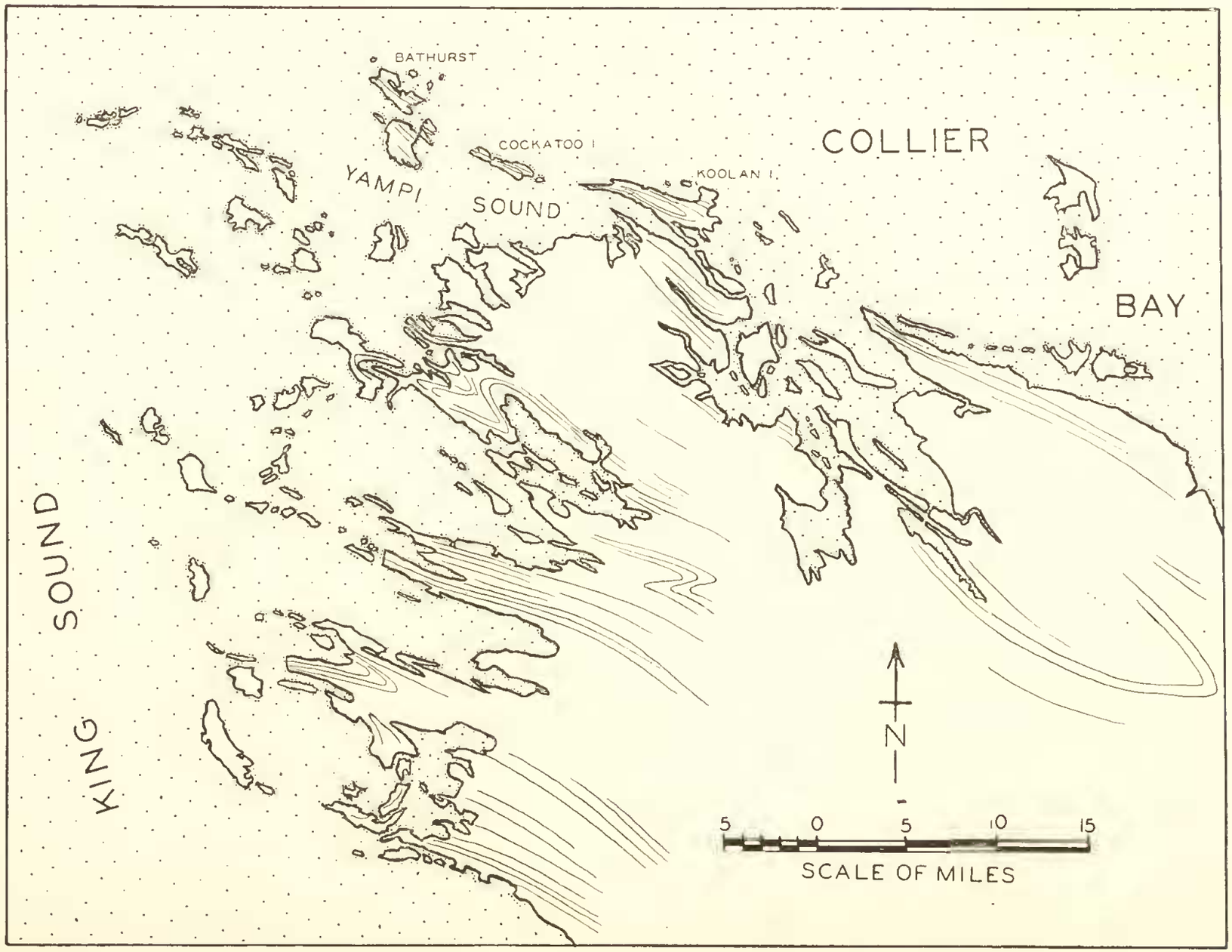

Fig. 1—Sketch map of the coast between Collier Bay and King Sound showing the relation between the strike lines of the sedimentary formations and the form of the coastline.

The porphyry and the schists are both deeply weathered to the high water mark (the top of the black band). The groundmass of the porphyry, and its felspar phenocrysts are generally severely kaolinized down to this level, i.e. to the surface of the platform. Where the porphyry is strongly jointed, this weathering permits easy undercutting of the jointed blocks. Where the joints are more widely spaced erosion of the more kaolinized rock along the joints leaves tors of relatively fresh rock, 4 to 5 ft. in diameter. Below the high water mark, the porphyry is fresh and unweathered, and is much harder and tougher than the kaolinized rock.

Similarly the schists are weathered to soft buff and brown clayey rocks down to the high tide mark, but are unweathered and much tougher below this level.

Fig. 2.—Nares Point, west of Koolan Island, showing the "black band", at low tide. *(H. Owen, photo.)*

The quartzites, by contrast, are little affected by weathering, and show no apparent difference in hardness or toughness above or below the high tide level. Moreover, they are generally harder than either the fresh porphyry or the fresh schist.

It appears, therefore, that the essential factor leading to the formation of these platforms (or rock terraces) is the pronounced softening and weakening that the porphyries and schists undergo on weathering in a tropical climate (with about a 60 inch rainfall). This weathering ceases abruptly at the mean high tide level, below which level the rocks in the cliffs are permanently wet, and so are preserved from weathering. Even the weakest of waves are able to take advantage of this abrupt change in hardness, where it exists, and cut a platform at high tide level.

Platforms on the Islands

The most striking development of platforms is found on small rocky islets in moderately sheltered positions. Many of them are "hat-shaped," consisting of a central core with vertical yellow or grey cliffs rising 10 ft. to 50 ft. above a flat black fringing platform from a few feet to 50 ft., or even 100 ft. wide. This platform ends on its seaward side in either a "low tide cliff" or more commonly, a steep, well defined and uniformly sloping bevel or ramp that continues down to reef level. The surfaces of the platforms may be smooth or irregular, according to the disposition and relative hardness (and composition) of the sediments involved. Occasionally they carry small rock stacks.

Fig. 3.—Platform about 100 ft. wide, with rock stacks, on a small island on the northern side of Bathurst Island. *(H. Owen, photo.)*

As along the inlets, the rocks are weathered down to the high tide mark (the top of the black band), but are practically unweathered below this level, and the surfaces of the platform coincide more or less with the base of the zone of weathering.

In places the "core" of weathered rocks has been completely eroded, leaving extensive flat black rock platforms, which are submerged at spring high tides, but are exposed in varying degree at other stages of the tide.

Some of the islands, notably the more southerly groups in the Archipelago, consist essentially of white quartzites, and these lack platforms, presumably because weathering does not induce any significant change in hardness at high tide level.

Pronounced platforms occur, also, on a number of exposed islands in the vicinity of Yampi Sound proper. These islands consist of quartzites and hematite quartzites interbedded with micaceous and chloritic schists. Here several factors appear to influence the formation of rock platforms (a) rock hardness, and (b) the disposition of the beds, and (c) the height of the cliffs.

The influence of rock hardness (and susceptibility to weathering) is well revealed along the exposed northern coasts of Koolan Island and Cockatoo Island, where there is a much stronger development of high tide mark platforms where schists are present at this level than where hematite quartzites form the cliffs.

The effect of disposition of the beds is well seen on McIntyre Island, Irvine Island, Bathurst Island, and the group of small islands tied by reefs to the northern side of Bathurst Island (Fig. 1). On Bathurst Island, particularly on the southern side, the coast consists of high vertical cliffs. On its western side massive beds of hematite quartzite and quartzite dip seawards at 30° or more. This section of its coast consists of smooth rock ramps running up the dip slopes. Commonly such a ramp is continuous with the slope of the island surface to 100 ft. or so above the high tide mark. Equally commonly the ramp ends in a "cliff" from 5 to 20 ft. high, whose face is at right angles to the slope of the ramp, the "cliff" having formed where a massive bed has been quarried away by the waves along a master joint at right angles to the bedding. The surfaces of some of the ramps are broken by a series of more or less closely spaced joints trending at right angles to the seaward edge.

On the northern sides of these islands however, where the dips are flatter and landwards, prominent platforms are developed, particularly on the small headlands that separate the indentations and occasional pocket beaches. Where the rocks in the platforms are thin bedded and of different hardness the platform surface is correspondingly irregular, but where the rocks are of uniform hardness, the platform surface is flat and relatively horizontal. Some platforms are up to 100 ft. wide (Fig. 3).

The platforms tend to be wider where they are backed by low cliffs than where they are backed by high cliffs, presumably because the volume of rock to be eroded at high tide is less, and a wider platform can be cut before high tide and low tide erosion forces balance. Possibly, also, the intensity of weathering of the rocks above high tide mark may be greater where the cliffs are low. The broadest platforms are those marking former small islands or tied islands, from which all rocks projecting above the high tide mark have been eroded.

Origin of the Platforms

These rock platforms bear a considerable resemblance to the rock platforms occurring at about high water mark along the coasts of Tasmania and south-eastern Australia. These platforms on the southern coasts are attributed variously to wave action (Edwards, 1941; 1951) and to the effect of "water layer levelling" (Hills, 1949). There has been some tendency to think of them as marking (measuring) a post-glacial eustatic fall of sea level (Fairbridge, 1954), but this explanation cannot be extended to the platforms in the vicinity of Yampi Sound, in view of the distinctly higher reduced level of the Yampi platforms.

There seems little doubt that many of the Yampi platforms owe their origin to wave action operating at a level where there is a sudden change from soft to hard rocks. This change occurs abruptly at the mean high tide level, below which level the rocks are permanently saturated with water and unweathered.

Such platforms are identical in character and origin with the "Old Hat" type of shore platform described by Bartrum (1935).

The length of time during which waves can erode at high tide level is of short duration during any one tide level, since the tide rises or falls at the rate of about 1 in. per minute. This is reflected in the bevelled seaward edges (ramps) of the platforms. The most vigorous erosion of the cliffs above the high tide level must occur during periods of storm coincident with periods of high tide. This must apply particularly along those sections of the island coasts that are fully exposed to storms.

These rock platforms on the exposed islands reveal a transition from the "Old Hat" type of platform, where the weathered state of the rock down to high tide level and its abrupt change at this level to hard fresh rock, are the dominating factors, to the "storm wave" platform proper, in which the rocks above the platform are unweathered, but are, in their fresh state, within the hardness range necessary to yield such rock platforms under the conditions of wave attack to which the coast is subject (Edwards, 1941).

The Yampi rock platforms are clearly not the outcome of a post-glacial eustatic fall of sea-level, since the sea level could scarcely fall 30 ft. at Yampi Sound, and only 15 ft. along the south-eastern coast of Australia; and they might be regarded as indirect proof that the

similar platforms occurring at about high tide level within the narrower tidal range along the southern coasts of Australia are simple erosion features, and equally independent of any eustatic movement of sea level.

It seems reasonable, therefore, to regard these platforms, like those of the southern coasts of the continent, as "storm wave platforms", and to see them as a normal stage in the maturing of a cliffed coastline where there is an appropriate relation between rock hardness, cliff height and the intensity of wave attack.

Acknowledgments

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